International Journal of Human Capital Management
E-ISSN 2580-9164
Vol. 7, No. 1, June 2023, p 74-85

Available online at
http://journal.unj.ac.id/unj/index.php/ijhcm

# SAFETY PLANNING AND SAFETY CONTROL ON SAFETY PERFORMANCE

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## ABSTRACT

*This study analyzes the influence of safety planning and safety control on safety performance. This study uses primary data from a survey using a questionnaire with a Likert scale of 1 to 5. This study uses 4,950 observational data with structural equation modeling analysis. This study uses safety planning and safety control as the independent variables and safety performance as the dependent variable. The results of this study indicate that safety planning has no significant effect on safety performance. Safety controls have a direct and significant effect on safety performance. This research is the first time in Indonesia to analyze the effect of safety planning and safety control on safety performance in building construction projects.*

***Keywords:*** *lean construction, safety planning, safety controls, safety performance.*

Received: 15 March 2023
Accepted: 2 May 2023
Publish: June 2023

**How to Cite:**
Wisnupradhono, A.G., et.al. (2023). Safety Planning and Safety Control on Safety Performance. *International Journal of Human Capital Management*, 7 (1), 74-85. https://doi.org/10.21009/IJHCM.07.01.6

## INTRODUCTION

In Indonesia, the number of work accidents is still quite high. Data from the Ministry of Manpower in 2020 shows that there were around 92,000 work accidents with 3,922 deaths. The Indonesian government is increasingly aggressive in issuing regulations related to occupational safety and health (K3). Technological developments enable new innovations in safety planning, safety control and safety performance. However, this can also pose new risks in terms of work safety. Therefore, it is important for companies to pay close attention to technological developments and pay attention to work safety aspects. Many companies in Indonesia are still experiencing limited resources in terms of budget, manpower and technology. Companies also need to pay attention to applicable regulations, technological developments, and pay attention to limited resources in an effort to manage safety planning, safety control and safety performance.

Several studies have explored the role of safety planning in improving safety performance. Research by Gao *et al.* (2023) found that safety planning is positively related to safety performance in the construction industry. Another study by (Yap *et al.*, 2022) found that effective safety planning, such as setting safety goals and allocating resources, is associated with reduced injury rates in the healthcare industry. Research on safety planning is focused on developing safety plans, which include strategies and procedures for identifying and mitigating potential hazards and risks. Research has shown that effective safety planning can improve safety outcomes in the construction industry. Research by (Al-Bayati *et al.*, 2020) found that safety planning is associated with improving safety culture and safety performance in the construction industry. Another study by Azmat (2020) found that effective safety planning, such as setting safety goals and allocating resources, is associated with reduced injury rates in the construction industry.

Safety controls refer to implementing safety measures and procedures to prevent accidents and injuries. Research has shown that effective safety controls can improve safety performance. Research by Xu *et al.* (2023) found that safety control measures, such as safety training and equipment maintenance, are positively related to safety performance in the manufacturing industry. Another study by Jamot & Park (2019) found that safety control measures, such as risk assessment and hazard identification, were associated with lower injury rates in the construction industry. Safety controls refer to implementing measures and procedures to prevent accidents and injuries in the workplace. Research has shown that effective safety control measures can improve safety outcomes in a variety of industries. Research by Long *et al.* (2022) found that safety control measures, such as safety training and equipment maintenance, are positively related to safety performance in the construction industry.

Another study by Hewing *et al.* (2020) found that safety control measures, such as risk assessment and hazard identification, were associated with lower injury rates in the construction industry. Safety performance refers to the results of safety management efforts, such as reduced accidents, injuries and deaths. A number of studies have investigated the factors that influence safety performance. Research by Gao *et al.* (2023) found that planning and control are significant predictors of safety performance in the construction industry. Another study by Gao *et al.* (2023) found that safety culture, safety management, and safety training are positively related to safety performance in the construction industry.

Systems theory argues that safety is a function of the interactions between various components in a system, such as people, equipment, procedures, and organizational culture. This

theory emphasizes the importance of considering the entire system when implementing safety measures, rather than focusing on individual components separately. Human factors theory focuses on the ways in which human behavior and cognition can influence safety outcomes. This theory recognizes that humans are fallible and prone to error, and that safety measures must be designed to accommodate human limitations and prevent errors from occurring. Safety culture theory argues that safety outcomes are influenced by the norms, values and beliefs that exist within an organization. This theory emphasizes the importance of promoting a positive safety culture that values safety and encourages safe behavior. Behavior-based safety is a model that focuses on changing individual behavior to improve safety outcomes. This model emphasizes the importance of providing feedback, reinforcement, and training to promote safe behavior.

This research is limited as to how these two concepts can be integrated effectively. Future research is expected to explore how organizations can integrate safety planning and safety control to achieve better safety outcomes. Lack of consensus on how safety performance should be measured. While traditional metrics, such as injury rates, are commonly used, they may not capture all safety performance. Future research may explore alternative methods of measuring safety performance, such as lead indicators or safety culture surveys. Safety interventions are usually implemented to improve safety outcomes, there is limited research on their effectiveness. Future research is also expected to explore the impact of various safety interventions, such as safety training or safety audits, on safety performance. With the rapid development of new technologies, there is a need to explore their potential role in safety management. Future research may examine how new technologies, such as artificial intelligence or wearables, can be used to improve safety planning, safety control and safety performance. Overall, these research gaps suggest that much remains to be learned about safety planning, safety control, and safety performance. Addressing this gap can help organizations develop more effective safety management strategies and ultimately improve safety outcomes.

## LITERATURE REVIEW

### Safety Planning

According to Chang *et al.* (2020) is the process of planning and implementing preventive measures to identify, evaluate, and reduce safety risks in the work environment. According to Mondal *et al.* (2020) is the process of developing, implementing, and evaluating work safety plans to reduce risks and injuries in the workplace. According to Sadeghi *et al.* (2023) is a systematic planning process to identify and analyze safety risks in the workplace and develop preventive action plans to reduce those risks. According to Zhang *et al.* (2019) is the process of developing a prevention plan to reduce risks and injuries in the workplace through identifying, evaluating, and managing safety hazards and risks. According to Fang *et al.* (2020) is the process of developing a structured and systematic safety plan to reduce the risk of injury and improve occupational health and safety. According to Hou *et al.* (2020) is a systematic planning process for identifying, evaluating, and mitigating safety risks in the workplace through the development and implementation of an effective preventive action plan. According to Hassanain *et al.* (2022) is the process of developing and implementing a systematic and holistic prevention plan to reduce safety risks in the workplace by considering technical, managerial and organizational factors. Then it can be synthesized that safety planning is a systematic planning process to identify safety hazards, evaluate risks, and formulate appropriate preventive measures to reduce risks and improve health and safety in the workplace.

### Safety Control

Safety controls are the implementation of systems and procedures designed to prevent accidents and reduce the risk of injury or damage in construction projects. It includes measures such as safety audits, inspections, and safety culture assessments (Long *et al.*, 2022). Safety control in construction involves the use of policies, procedures and technology to prevent accidents, injuries and illnesses in the workplace (Jamot & Park, 2019). Safety controls refer to the measures that construction companies use to minimize hazards and risks in the workplace. This may include safety training, protective equipment, and monitoring and reporting systems (Gao *et al.*, 2023). Safety controls involve identifying potential hazards, assessing risks, and implementing measures to eliminate or reduce risks. This includes policies and procedures, training, personal protective equipment, and monitoring and reporting systems (Jin *et al.*, 2019). Safety controls include the procedures, protocols and technologies implemented to prevent accidents, injuries and deaths in construction projects. This may include safety training, hazard identification and assessment, and safety performance metrics (Xu *et al.*, 2023). Safety controls refer to the steps taken to manage and mitigate the risks associated with construction activities. This includes developing safety policies and procedures, training, and using technology to identify and address potential hazards (Hewing *et al.*, 2020). Safety controls involve implementing procedures, systems and technology to prevent accidents and injuries on construction sites. This may include the use of safety plans, hazard assessments, and monitoring of safety performance (Jamot & Park, 2019). So, it can be synthesized that safety control refers to the application of procedures and systems to manage and mitigate risks associated with construction activities, including hazard identification, risk assessment, and control measures.

### Safety Performance

According to Almohassen *et al.* (2023) is the output of a series of measures designed to prevent and reduce injuries and accidents in the workplace. According to Newaz *et al.* (2023) is the degree to which an organization achieves its goals in safeguarding the health and safety of its employees and the place they work. According to Li *et al.* (2023) are the overall results of performance and safety practices in the workplace that contribute to reducing work risks and injuries. According to Onubi *et al.* (2023) are quantitative and qualitative achievements in efforts to prevent work accidents and injuries. According to Gao *et al.* (2023) are the results of responses, actions, and policies aimed at preventing work incidents and accidents. According to Arzahan *et al.* (2022) is the result of performance in implementing policies, procedures and actions designed to prevent accidents and adverse events. According to Zhou *et al.* (2022) is a qualitative and quantitative assessment of the extent to which safety and health risks in the workplace are controlled and accidents are prevented. So, it can be synthesized that safety performance refers to a measure of organizational success in preventing accidents, injuries and disturbances related to safety in the workplace environment.

## RESEARCH HYPOTHESIS AND MODEL REVIEW

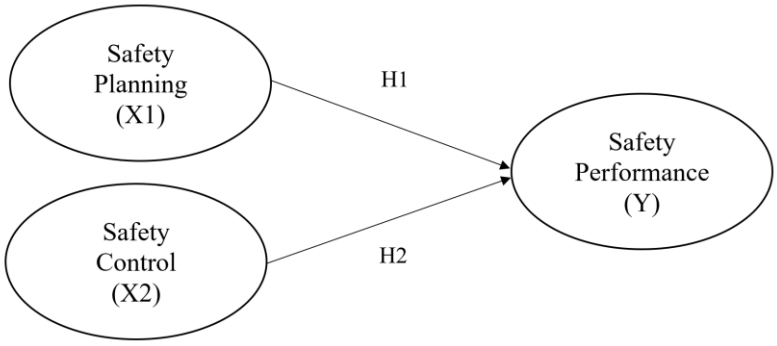
### The effect of safety planning on safety performance.

The effect of safety planning on safety performance can be analyzed in various contexts, such as organizational, industrial, or individual levels. Generally, safety planning refers to the process of developing strategies, procedures, and protocols to identify and mitigate potential hazards and risks in order to prevent accidents, injuries, or other safety incidents (Gao *et al.*, 2023). Based on previous research, the following hypotheses were built:
H1: safety planning has a positive effect on safety performance

**The effect of safety control on safety performance.**

Safety control refers to the measures, systems, and processes put in place to identify, assess, and manage safety risks and hazards within an organization or environment (Gao *et al.*, 2023). It is important to consider other factors that may influence safety outcomes, such as leadership commitment, resource allocation, employee training, and communication. Organizations should strive to implement comprehensive safety control measures tailored to their specific needs and continuously evaluate and improve them to achieve optimal safety performance. Based on previous research, the following hypotheses were built:
H2: safety control has a positive effect on safety performance.

Based on the review of relevant theory and research above, the proposed research model is described in Figure 1 below.




Regression equation is: $Y = \alpha 0 + \gamma 1\ X1 + \gamma 2\ X2 + \zeta$

**Figure 1. Research Framework**

## METHODOLOGY

The research design used in this study is a causality descriptive research design. Causal research design aims to analyze the relationship between variables in a study or to find out how a variable can affect changes in other variables (Hair Jr *et al.*, 2021). In this study there are exogenous (independent) variables, namely safety planning and safety control, also endogenous (dependent) variables, namely safety performance. The research questionnaire was filled out online for data collection. The research population is Building Contruction's Projects in DKI Jakarta, Indonesia. Data collection, processing and analysis will be carried out in 2023. The sampling method uses Non-Probability Sampling with stratified random sampling. The number of respondents in this study was 150 people, the sample size was taken based on (Hair Jr *et al.*, 2021).

**Table 1**
**Demographics of Respondents**

| Demography | Categories | Responden | Percentage |
|---|---|---|---|
| Gender | Male | 90 | 60% |
| | Female | 60 | 40% |
| Ages | 18 – 30 years | 150 | 100% |
| | 31 – 40 years | - | - |
| | 41 – 50 years | - | - |
| | 51 – 60 years | - | - |

| Demography | Categories | Responden | Percentage |
|---|---|---|---|
| Education Level | > 60 years | - | - |
| | Diploma | - | - |
| | Bachelor's degree | 150 | 100% |
| | Master's degree | - | - |
| | Doctorate | - | - |
| Work Experience | Less than 5 years | 140 | 93% |
| | 6 – 10 years | 10 | 7% |
| | 11 – 15 years | - | - |
| | 16 – 20 years | - | - |
| | 21 – 25 years | - | - |
| | 26 – 30 years | 0 | |
| | Over 30 years | - | - |
| Management Hierarchy | Senior managers | - | - |
| | Middle managers | - | - |
| | Lower managers | 42 | 28% |
| | Professionals | 12 | 8% |
| | Others | 96 | 64% |

This study uses the Structural Equation Model Partial Least Square (SEM-PLS) analysis tool with two measurement models (Hair Jr *et al.*, 2021), namely Outer Model Analysis with five parameters, Inner Model Analysis with four parameters, as well as analyzing models and testing hypotheses. Evaluation of the Measurement Model (Outer Model Analysis) uses five parameters, including Convergent Validity Value, where the loading factor value must be above 0.70, then it is said to be valid. The second is Average Variance Extracted (AVE) with an expected AVE value above 0.50, meaning that the higher the AVE value, the variance caused by errors in model measurement is smaller than the variance caused by each construct captured by the model. Third is Discriminant Validity, the loading factor value is greater than the cross-loading value or you can also use the Fornell-Lacker Criterion value, where the criterion value is greater than the correlation value to other constructs. The fourth is Reliability Analysis using the Composite Reliability (CR) value, and it is expected that the CR value is greater than 0.70, so the latency is said to be reliable. In addition, finally, Cronbach's Alpha with the expected value is Cronbach's Alpha greater than 0.60.

So, hypothesis testing involving relationships between constructs will only be reliable or valid if the measurement model explains how these constructs are measured (Hair Jr *et al.*, 2021). Significance testing is the process of testing whether a particular outcome occurs by chance. The critical values for this level of significance and the one-tailed test are 1.65, respectively. The significance test using the t-statistic value (t value) for a one-tailed test is 1.65. For the significance level of the p-value is 5% (0.05), it means that it is said to be significant if the p-value is less than 0.05.

## RESULTS AND DISCUSSION

Respondents were 150 HSE employees from five building construction projects in Jakarta, consisting of 60 people (40%) women, and 90 people (60%) were men. The number of respondents from each project is 30 people. Furthermore, respondents aged 18 to 30 years were as many as 150 people (100%). For the educational level of all respondents is S1 (bachelor's degree). Respondents studied were 10 people who had worked from 6 to 10 years and 140 people who worked less than 5 years. Respondents of HSE employees who held the position of middle manager in the project were 60% (90 people), 50 people (33.3%) were lower managers and 10 people (6.7%) were professional employees.

In this study, if each construct has an AVE > 0.50, the minimum acceptable loading factor size is 0.70. Based on the SmartPLS 3.0 processing results shown in Figure 2, the loading factor values for all indicators are above 0.70. Therefore, the convergent validity model in this study meets the requirements. The loadings, cronbach's alpha, composite reliability, and AVE values for each complete construct are in table 1.

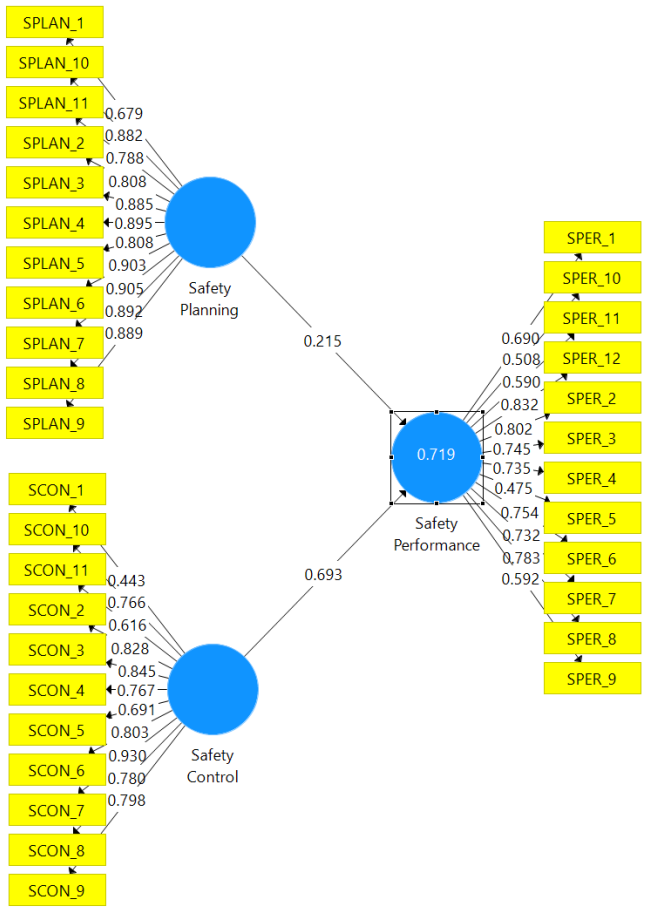



**Figure 2. Outer Model Analysis Results**

**Table 2**
**Convergent Validity**

| Contruct | Indicators | Factors Loadings | Cronbach's Alpha | Composite Reliability | AVE |
|---|---|---|---|---|---|
| Safety Planning | SPLAN_1 | 0,679 | 0,961 | 0,966 | 0,724 |
| | SPLAN_2 | 0,808 | | | |

| Contruct | Indicators | Factors Loadings | Cronbach's Alpha | Composite Reliability | AVE |
|---|---|---|---|---|---|
| | SPLAN_3 | 0,885 | | | |
| | SPLAN_4 | 0,895 | | | |
| | SPLAN_5 | 0,808 | | | |
| | SPLAN_6 | 0.903 | | | |
| | SPLAN_7 | 0.905 | | | |
| | SPLAN_8 | 0,892 | | | |
| | SPLAN_9 | 0,889 | | | |
| | SPLAN_10 | 0,882 | | | |
| | SPLAN_11 | 0,788 | | | |
| Safety Control | SCON_1 | 0,443* | 0,925 | 0,937 | 0,580 |
| | SCON_2 | 0,828 | | | |
| | SCON_3 | 0,845 | | | |
| | SCON_4 | 0,767 | | | |
| | SCON_5 | 0,691* | | | |
| | SCON_6 | 0,803 | | | |
| | SCON_7 | 0.930 | | | |
| | SCON_8 | 0,780 | | | |
| | SCON_9 | 0,798 | | | |
| | SCON_10 | 0,766 | | | |
| | SCON_11 | 0,616* | | | |
| Safety Performance | SPER_1 | 0,690* | 0,901 | 0,916 | 0,584 |
| | SPER_2 | 0,802 | | | |
| | SPER_3 | 0,745 | | | |
| | SPER_4 | 0,735 | | | |
| | SPER_5 | 0,475* | | | |
| | SPER_6 | 0,754 | | | |
| | SPER_7 | 0,732 | | | |
| | SPER_8 | 0,783 | | | |
| | SPER_9 | 0,592 | | | |
| | SPER_10 | 0,508* | | | |
| | SPER_11 | 0,590* | | | |
| | SPER_12 | 0,832 | | | |

Discriminant validity tests are conducted to ensure that the concept of each latent variable is different from other latent variables. The model is said to have good discriminant validity if the AVE value for each exogenous construct exceeds the correlation between constructs and other constructs. The results of the discriminant validity test using the AVE value by looking at the Fornell-Larcker Criterion value, namely in table 1. The results of the discriminant validity test in Table 1 show that the AVE value for all constructs is higher (0.724; 0.580; 0.584) > 0.50 than the correlation with other potential constructions (according to the Fornell-Larcker Criteria). Therefore, it can be concluded that the model has met discriminant validity.

**Table 3**
**Discriminant Validity (Fornell-Larcker Criterion)**

| | Safety Planning | Safety Control | Safety Performance |
|---|---|---|---|
| Safety Planning | 0,851 | | |
| Safety Control | 0,642 | 0,762 | |
| Safety Performance | 0,660 | 0,832 | 0,696 |

Testing the hypothesis by looking at the path coefficient of the bootstrapping analysis results by comparing the t-statistics with the t-table. The hypothesis accepts the t-statistic value > t-table (1.65). The results of the complete bootstrapping analysis on the path coefficient with a 90% confidence level are shown in Figure 3. The path coefficient value indicated by the t-statistic must be higher than the t-table value with an alpha significance level of 5% (0.05) and the t value above 1.65.

The t-statistic values for all paths in the studied structural model. In summary, the results of the path coefficient t-test analysis are shown in table 3. The path coefficient t-test analysis (Table 3) shows that safety planning hasn't direct and not significant effect on safety performance (H1: Rejected, t=0.716 and p=0.015). Safety control has a direct and significant effect on safety performance (H2: Accepted, t=2.060 and p=0.040).

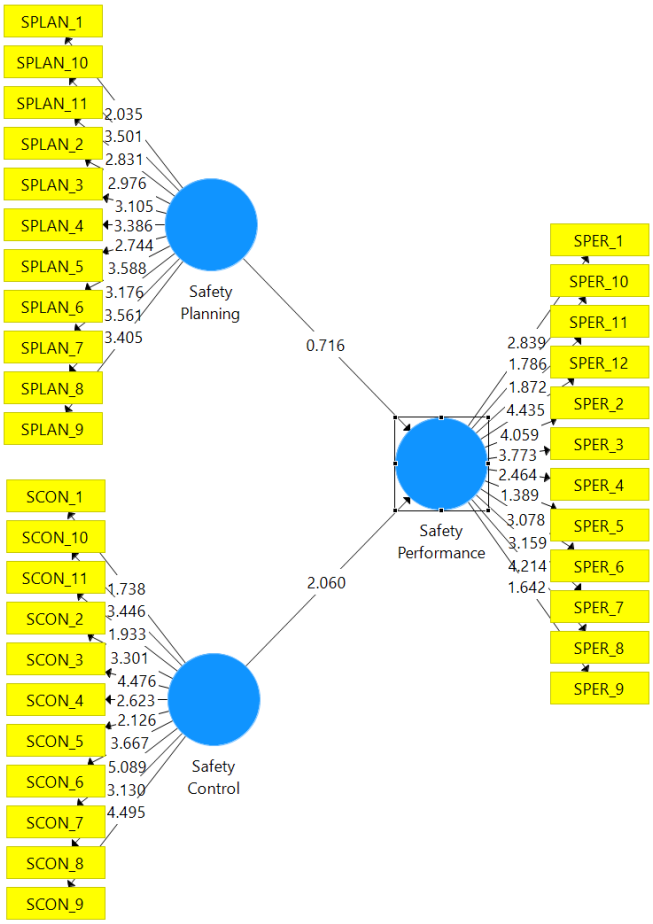



**Figure 3. Inner Model Analysis Results**

**Table 4**
**Coefficient of Determinant Score (R-square)**

| | R-square | R-square adjusted |
|---|---|---|
| Safety performance | 0,719 | 0,672 |

F-square ($f^2$) is calculated to measure the significance of the partial effect of exogenous variables on endogenous variables, the estimated value of $f^2$ is 1.130 and 1.006 indicating that the value of the effect is weak, moderate, and strong (Cohen, 1988). Based on the results of Table 5, the $f^2$ value of the safety planning variable on safety performance is 1.130 (medium), the safety control variable on safety performance is 1.006 (strong).

**Table 5**
**Assessing the level of effect size (f2)**

| Relationship | $f^2$ | Conclusion |
|---|---|---|
| Safety planning -> Safety performance | 1,130 | Moderate |
| Safety control -> Safety performance | 1,006 | Strong |

Finally, Q-square (Q2) measures how well the model produces the observed and estimated parameters. If the $Q^2$ value is greater than 0 (zero), then the model is considered to have a relevant predictive value. In this study, the results of the $Q^2$ calculation were 0.474 for safety planning and 0.482 for safety control and for safety performance of 0.332, which means that the variables in this study have a good predictive correlation because the $Q^2$ value exceeds zero; the results are shown in table 6.

**Table 6**
**Q-Square Model Fit Results**

| | $Q^2$ (=1-SSE/SSO) |
|---|---|
| Safety planning | 0,474 |
| Safety control | 0,482 |
| Safety performance | 0,332 |

## CONCLUSION

Research shows that the presence of good safety planning has no effect on safety performance. Safety planning which includes risk identification, development of safety procedures, and adequate resource allocation can help reduce accident risk and improve workplace safety, because everything depends on action in the field. Safety controls and safety performance: Research shows that the implementation of effective safety controls also has a positive effect on safety performance. Safety control involves the use of proper personal protective equipment, good safety training, close supervision, and consistent and disciplined application of safety procedures. Several studies have shown that good interaction between safety planning and safety control can have a stronger impact on safety performance than implementing the two separately. Good coordination between safety planning and implementing effective safety controls can create a safer work environment and improve safety performance. However, each study has a different context, methodology, and sample. Conclusions may vary depending on this variation. In addition, safety at work is influenced by many other factors such as safety culture, management commitment, employee participation and environmental factors. Therefore, to obtain a more comprehensive and accurate conclusion, a thorough review of various relevant studies in this field is required.

This study only examined a relatively small sample with the selected region, only projects in Jakarta due to time constraints, so it was lacking in discussing the results of this study. This research is limited as to how these two concepts can be integrated effectively. This research still

lacks consensus on how safety performance should be measured. Safety interventions are usually implemented to improve safety outcomes, there is limited research on their effectiveness. With the rapid development of new technologies, there is a need to explore their potential role in safety management.

Future research is expected to explore how organizations can integrate safety planning and safety control to achieve better safety outcomes. Future research is also expected to explore the impact of various safety interventions, such as safety training or safety audits, on safety performance. Future research may examine how new technologies, such as artificial intelligence or wearables, can be used to improve safety planning, safety control and safety performance. Future research may explore alternative methods of measuring safety performance, such as lead indicators or safety culture surveys.

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